UDC 621.313

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CHARACTERISTICS OF THE PROCESSES OF ENERGY TRANSFORMATION AND THE INDICATORS OF ITS CONVERSION

Abstract. *The nature of the quality of the process of energy transformation in the electrical motors and also the indicators of its conversion are considered. We also show that the coefficients existing of the quality of energy transformation are effective indicators which take into account the links between the quality of energy transformation and the performances of the electric machines. In the same way the need for establishing the bond between the qualitative and quantitative characteristics of conversion was well proven.*

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ХАРАКТЕРИСТИКИ ПРОЦЕСІВ ПЕРЕТВОРЕННЯ ЕНЕРГІЇ, А ТАКОЖ ПОКАЗНИКИ ЙОГО ПЕРЕТВОРЕННЯ

Анотація. *Розглянуто природу процесу якості перетворення енергії в електричних двигунах і показники її перетворення. Показано, що існуючі коефіцієнти якості перетворення енергії є ефективними показниками, які враховують взаємозв'язки між якістю перетворення енергії і працездатністю електричної машини. Доведено необхідність врахування взаємозв'язків між якісними і кількісними характеристиками перетворення.*

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ХАРАКТЕРИСТИКИ ПРОЦЕССОВ ПРЕОБРАЗОВАНИЯ ЭНЕРГИИ, А ТАКЖЕ ПОКАЗАТЕЛИ ЕГО ПРЕОБРАЗОВАНИЯ

Аннотация *Рассмотрена природа процесса качества преобразования энергии в электрических двигателях и показатели ее преобразования Показано, что существующие коэффициенты качества преобразования энергии являются эффективными показателями, которые учитывают взаимосвязи между качеством преобразования энергии и работоспособностью электрической машины. Доказана необходимость учета взаимосвязей между качественными и количественными характеристиками преобразования.*

The conversion of electrical energy in the electrical motors is carried out according to the Maxwell's equations and the law of Amp.The quality of the energy of the delivery systems of electrical energy largely determines the effectiveness of operation of the electrical motors (EM) [8, 9]. The indicators of effectiveness of operation are defined according to the quality of electrical energy by normative documents [1]. However, it is known that [2], even with a symmetrical and sinusoidal power supply of the electrical motor having an electric or magnetic parametric asymmetry, other tangential forces and electromagnetic moments including those of pulsatory nature appear. These moments of torque are the result of interaction of various harmonics of the time of the principal magnetic field and other magnetic fields according to the harmonics of the time of the stator and rotor currents appeared because of the imbalance of the engine. Thus, in the foreground, the quality of the conversion of electrical energy appears. With this, there does not exist currently any quality control of transformation energy in the electrical motors. In the same way the systems of indicators allowing the quantitative evaluation of the value of the energy transformation are absent today.

Taking into account the urgent need for the creation of a system of evaluation of the quality of transformation energy, and by holding account that the quality of energy does not have any absolute scale and being characterized not by a number but by a whole of various characteristics, We were proposed analytical coefficients describing the various aspects of a process - process of energy transformation. These coefficients are called“indicating quality of energy transformation” (IQCE) whose principles are given [6, 7]. Their base is consisted components of time and integral components of the moment of the couple and power.

On the basis of coefficient and these indicators, it was proposed to employ it for the evaluation of the state of the electrical motors, which have a certain form of parameter of asymmetry acquired in operation or repair. However, the coefficients indicated were proposed without suitable justification of the nature of the or not qualitative transformation of energy in the electrical motor. For this reason in the years to come will appear more and more of the new IQCE which will not give a valid opinion on the nature of the processes of energy transformation and especially - the corresponding estimate for the E.M [3, 4].

There exist research tasks, for example [5], in which it was carried out only a test of implementation of the IQCE previously developed with the state of the electrical motor. Thereafter, we deduced that the state of the electrical motor is carried out containing the logical equations including IQCE, of the harmonic components of the consumption and the additional coefficients. With this, the latter were taken again without adequate justification.

Thus, it should be noted that to date there does not exist well defined structure of the indicators characterizing the qualitative and quantitative aspects

process of energy transformation in the electric machine.

The objective of this work is the analysis of the quality of the physical principles of the conversion of electrical energy of the engines and the indicators of its transformation.

The examination of the nature of the mechanism of generation of the processes of conversion can be carried out containing an analysis of interaction of the magnetic fields. For example, in the case of imbalance of the phases of the rotor of an asynchronous motor , we consider the generation of the variable components of the moment of the couple and the rotational
frequency with a symmetrical and sinusoidal supply voltage (figure 1).

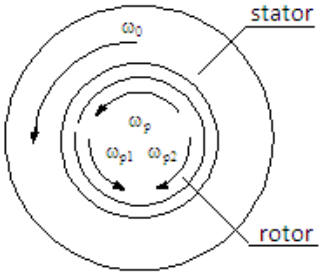

Fig.1. Rotation direction of stator and rotor fields of AC motor with asymmetry in the rotor resistance

Since in this case, in the rotor there will be formation of two systems of the currents and of flows with direct and opposite sequence then the moment of the alternate couple of the engine can be presented in the form:

$$M'(t) = c \cdot I_{c1} I_{p2} \sin(2\omega_0 st), \qquad (1)$$

Where $2\omega_0 s = \Delta\omega_{02} = \omega_0 - \omega_p + \omega_{p2}$ - the difference speeds of the stator, rotor field and of the rotor opposite field.

The variation of the slip according to time has also a harmonic component

$$s(t) = s + \Delta s \cdot \sin(2\omega_0 st), \qquad (2)$$

In this case, we can also observe “beat” of the current with the frequencies according to the slip.

Let us consider for example the case or except for the fundamental harmonic of frequency ω_{01}, the tension contains in more one second harmonic of frequency ω_{02} (Fig. 2). This is typical by the fact that the AC motor is fed by a converter of energy as the tension contains harmonics due following the phenomenon of commutation or modulation. Thereafter, the directions of rotation can be agreed or be opposed as shown in the figure. In this diagram, the interaction of the fields with frequencies
occurs ω_{01} and ω_{p1}; ω_{02} and ω_{p2}; ω_{02} and ω_{p1}; ω_{01} and ω_{p2}. The first two pairs create fixed couples in time. The two other components generate alternating couples.

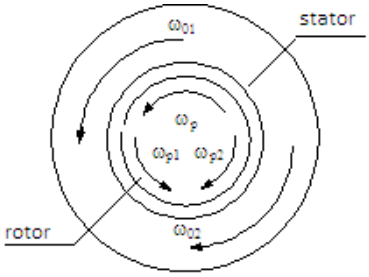

Fig.2. Rotation direction of stator and rotor fields of AC motor powered with double frequency voltage

Difference in speed between the fields of the stator and the rotor:

$$\begin{aligned} \Delta\omega_1 &= \omega_{01} - \omega_p - \omega_{p2} = \omega_{01} - \omega_{02}; \\ \Delta\omega_2 &= \omega_{02} + \omega_p + \omega_{p2} = \omega_{01} + \omega_{02}. \end{aligned} \qquad (3)$$

The components of the couple alternating with rotation of the fields in opposite direction can be presented in the form:

$$M_\Sigma(t) = c \cdot I_{c1} I_{p2} \sin[(\omega_{01} + \omega_{02})t]. \quad (4)$$

When the magnetic fields turn in the same direction, the expression (4) becomes:

$$M_\Sigma(t) = c \cdot I_{c1} I_{p2} \sin[(\omega_{01} - \omega_{02})t]. \quad (5)$$

The variation of the slip according to time has also a harmonic component:

$$\Delta s(t) = \Delta s_m \sin[(\omega_{01} + \omega_{02})t] \qquad (6)$$

Where Δs_m the amplitude of the alternate component of the slip

While using (2) and (6), we can obtain the currents of the stator and the rotor according to all the spinning field patterns

Thus it is clear that the parameters of the network and the electrical motor determine all the spectrum of the electromechanical interactions.

However, one should take into account that the nature of the processes of energy transformationinfluences on the dynamic properties of the electrical motor. The analysis of the studies of research made it possible to confirm that the estimates of the quality of energy transformation and the indicators of its conversion depend primarily on the dynamic properties of the electrical motor and must be taken into account.

It is certain that the base of natures of the quality of energy transformation should put back on the electromechanical and electromagnetic interactions fields and couples generated by the latter.

The absence of a clear evaluation of the quality of the processes of energy transformation in the electrical motors indicates the complexity of these processes on the one hand and the characteristics of posting of these processes in systems and equipment particular on the other hand.

That requires to find indicators suitable of the quality of energy transformation and also the development of the tools mathematical corresponding allowing their qualitative and quantitative evaluation. It can be a question, for example of the methods based on an analysis of the variables of state, but according to us, being given the nature of the energy transformation, the best results

are obtained on the basis of analysis of the instantaneous power and the moment of the couple developed by the electrical motor.

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Received 01.07.2011

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